EMU Alignment System

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DOE / NSF Review

5-6 June '02

Progress since May '01

Sensor development (DCOPS)

- Built & tested 25 sensors with a variety of filters & shades
- Designed and built new readout electronics
- Developed calibration procedure

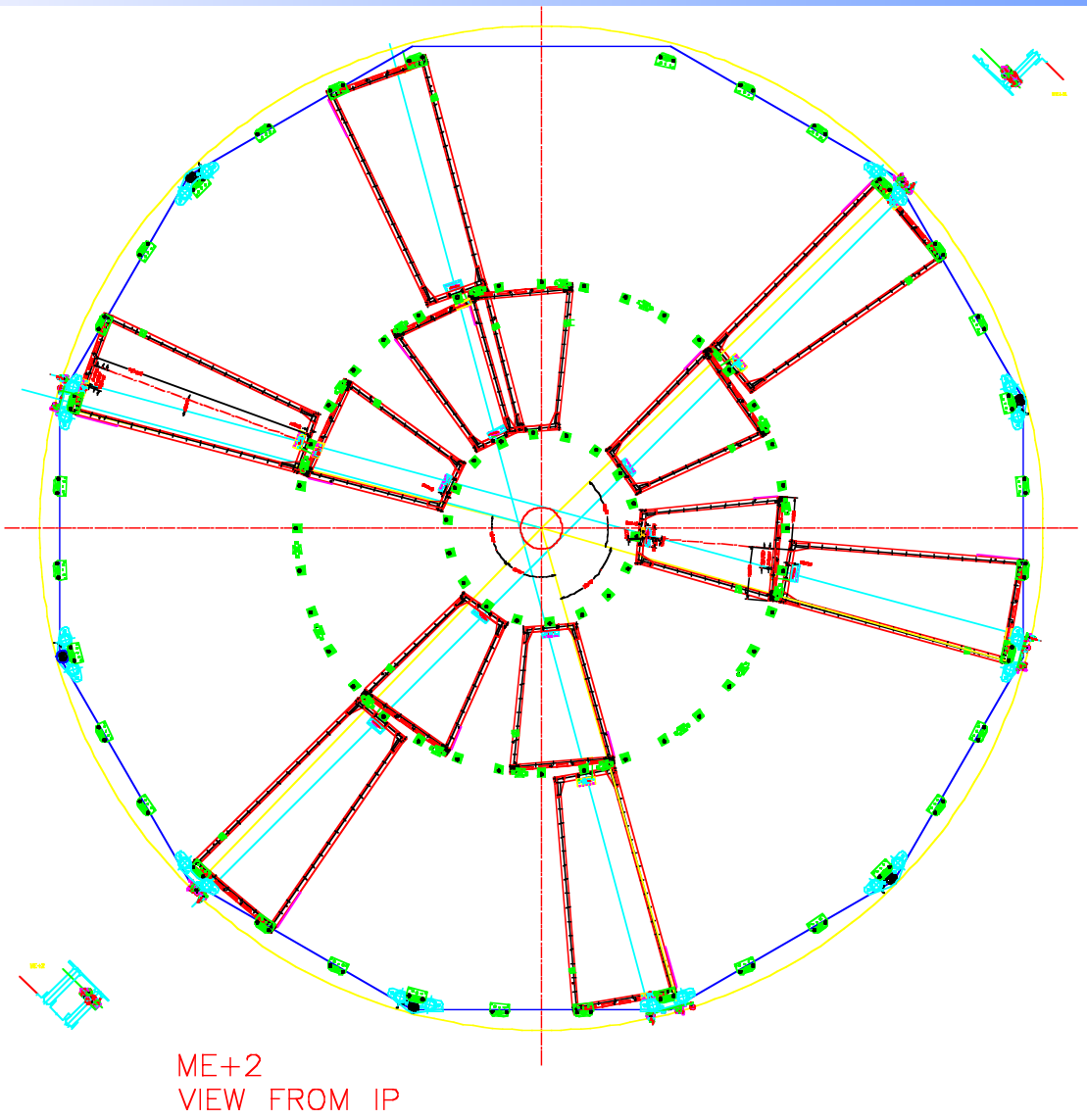
SLM (Straight Line Monitor) tests

- Realistic setup with 10 DCOPS sensors
- Full readout of DCOPS sensors and a variety of analog sensors (temp, inclinometer, radial position, proximity, etc.)

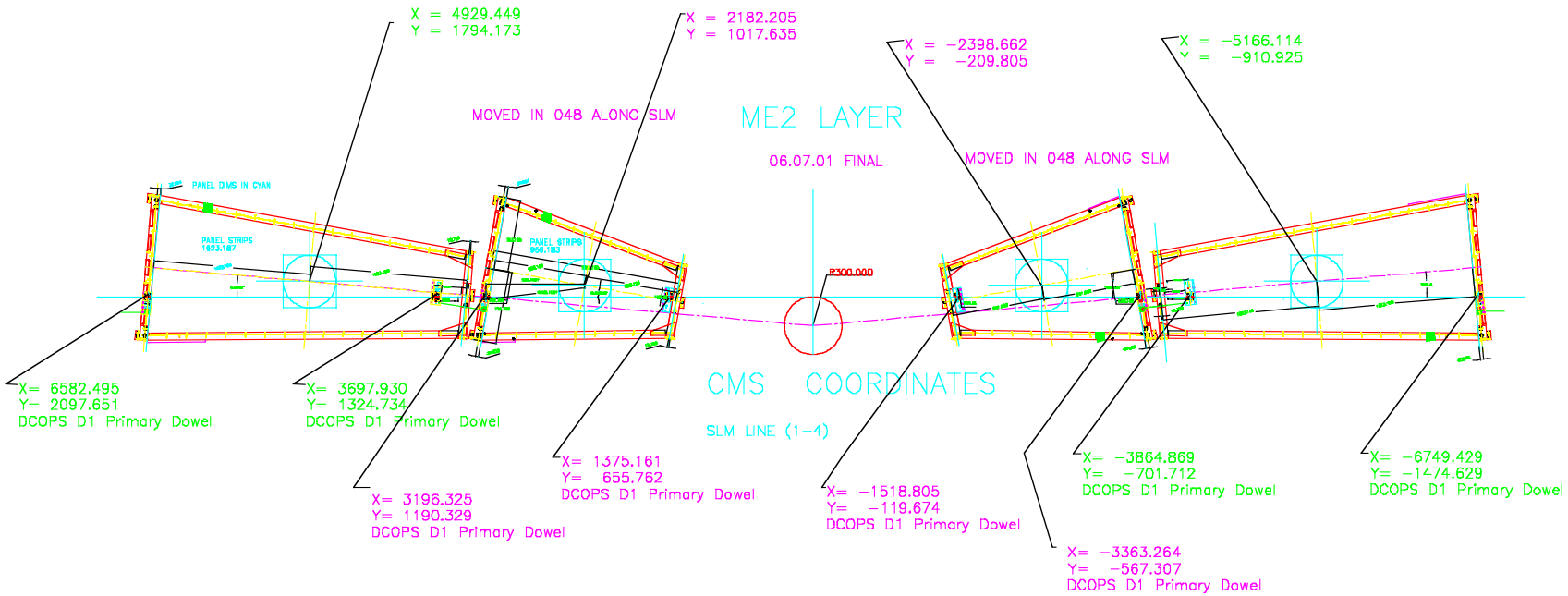
Engineering Design Review (CERN)

- Approval for production

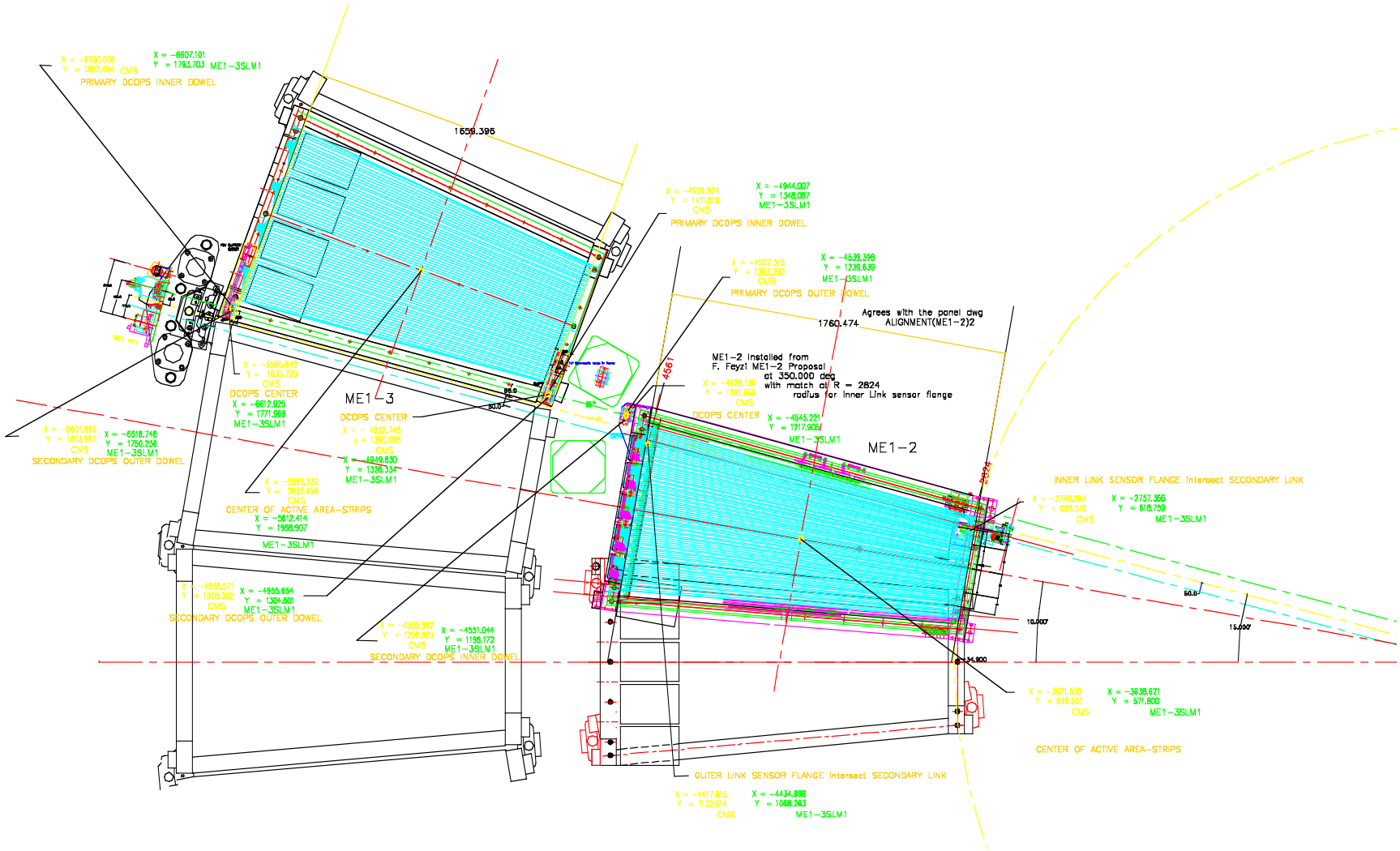
ME2 alignment



ME2 SLM line


X = 4929.449
Y = 1794.173
X = 2182.205
Y = 1017.635
X = −2398.662
Y = −209.805
X = −5166.114
Y = −910.925
MOVED IN 048 ALONG SLM
ME2 LAYER
06.07.01 FINAL
MOVED IN 048 ALONG SLM
PANEL DIMS IN CYAN
PANEL STRIPS 1623.167
PANEL STRIPS 966.183
R300.000
CMS COORDINATES
SLM LINE (1−4)
X= 6582.495
Y= 2097.651
DCOPS D1 Primary Dowel
X= 3697.930
Y= 1324.734
DCOPS D1 Primary Dowel
X= 3196.325
Y= 1190.329
DCOPS D1 Primary Dowel
X= 1375.161
Y= 655.762
DCOPS D1 Primary Dowel
X= −1518.805
Y= −119.674
DCOPS D1 Primary Dowel
X= −3363.264
Y= −567.307
DCOPS D1 Primary Dowel
X= −3864.869
Y= −701.712
DCOPS D1 Primary Dowel
X= −6749.429
Y= −1474.629
DCOPS D1 Primary Dowel

ME 1 Alignment



Alignment Staging

US-CMS requested a staging of alignment

- **Related to cost overruns in EMU**
- **Spent months trying to find a staging scenario with small impacts**
- **Finally agreed on a staged design:**
  - Keep full alignment SLMs for stations 1 & 2
  - Eliminate SLMs for station 3 (except for electronics)
  - Remove all engineering funding (physicists must do the engineering)
  - Maintain possibility of recovering the ME3 alignment SLMs at a later time
  - Save $200K of production costs (approx. 1/3)

Sensor technology

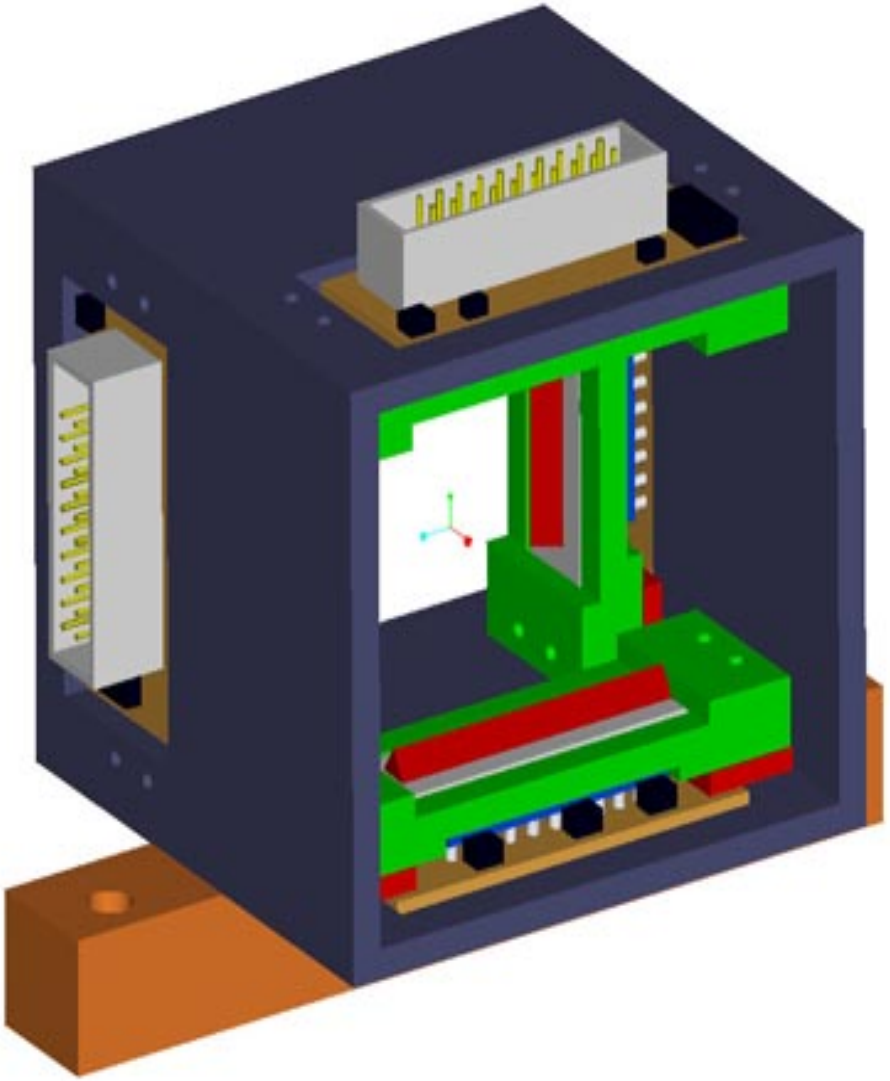
Design requirement for our system

- Many (up to 10) sensors in a line must all be capable of locating the laser beam
- Present transparent sensors are not transparent enough and projected developments do not match our schedule

Design “standard tech” sensor

- Develop design using conventional items (relatively low risk)
- 4 linear CCDs mounted in a window frame
- Cross-hair laser beam
- Readout with DSP processor and serial I/O
- Digital CCD optical position sensor (DCOPS)

DCOPS sensor box



- 64mm x 64mm Al box with black anodizing
- 4 CCD arrays mounted at right angles to laser
- Red wedge filters on face of CCDs - bidirectional
- Standard mounting configuration

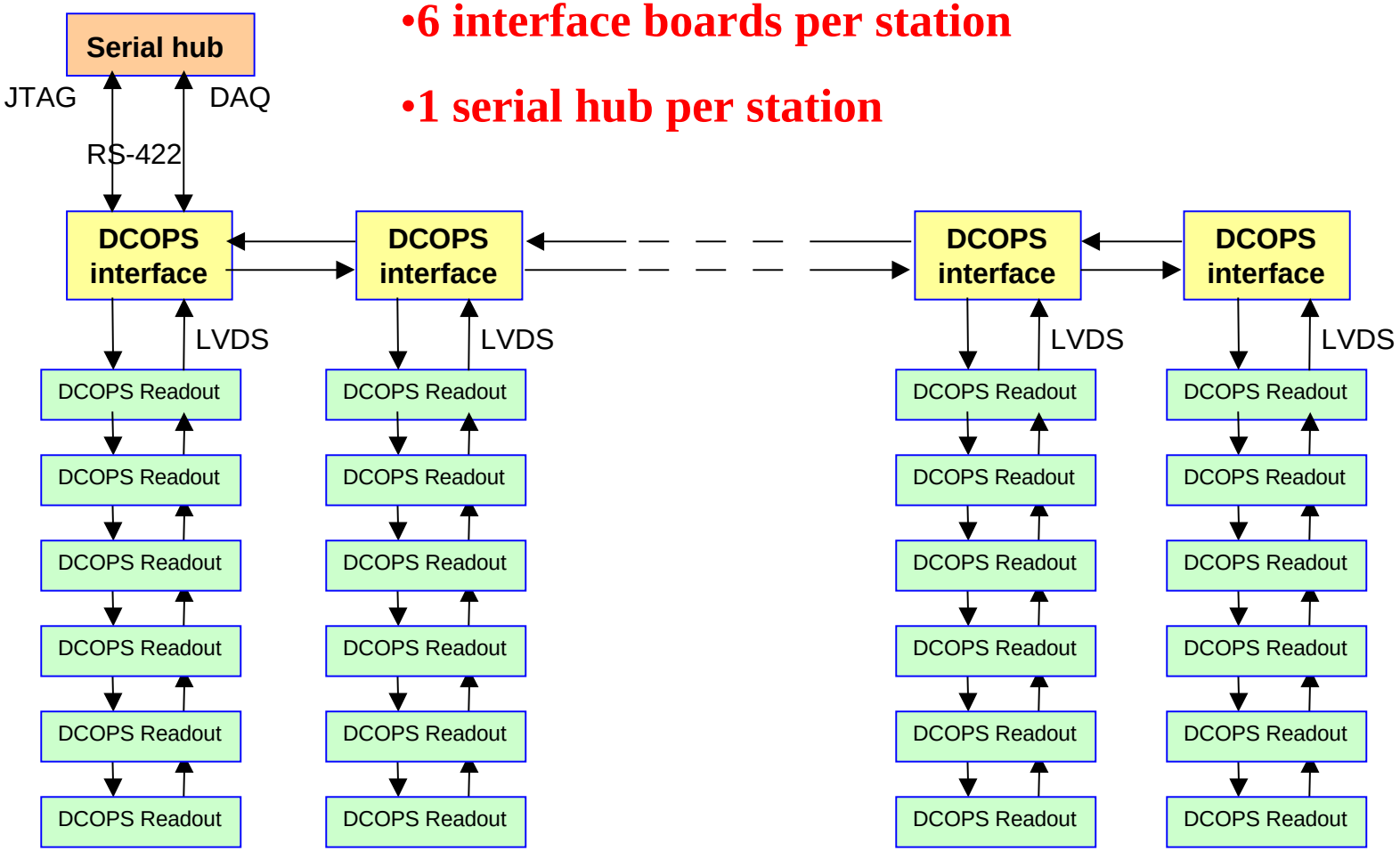
DCOPS Developments

Mechanical improvements

- Sensor wedge, optical filters, laser attenuation filters
- Non-shadowing aperture solutions
- New design of CCD readout boards links 4 together inside box -- much better cabling layout
- Need slightly larger box -- build & test prototype box and front-end board

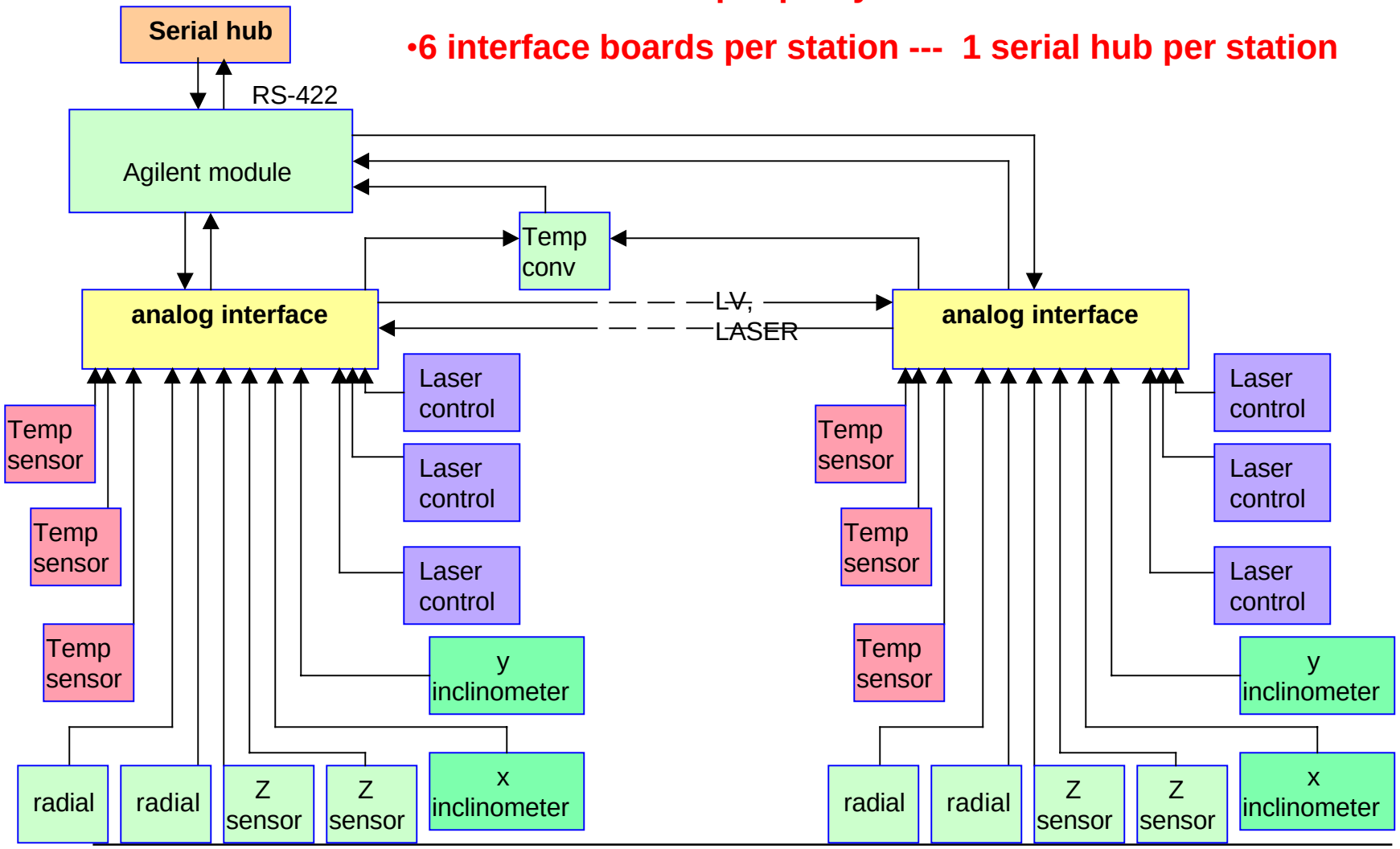
DCOPS Readout Scheme

- **Interface board at periphery of disk at end of each SLM**
- **6 interface boards per station**
- **1 serial hub per station**



Analog Readout Scheme

- **Interface board at periphery of disk at the end of each SLM**
- **6 interface boards per station --- 1 serial hub per station**



Electronics developments

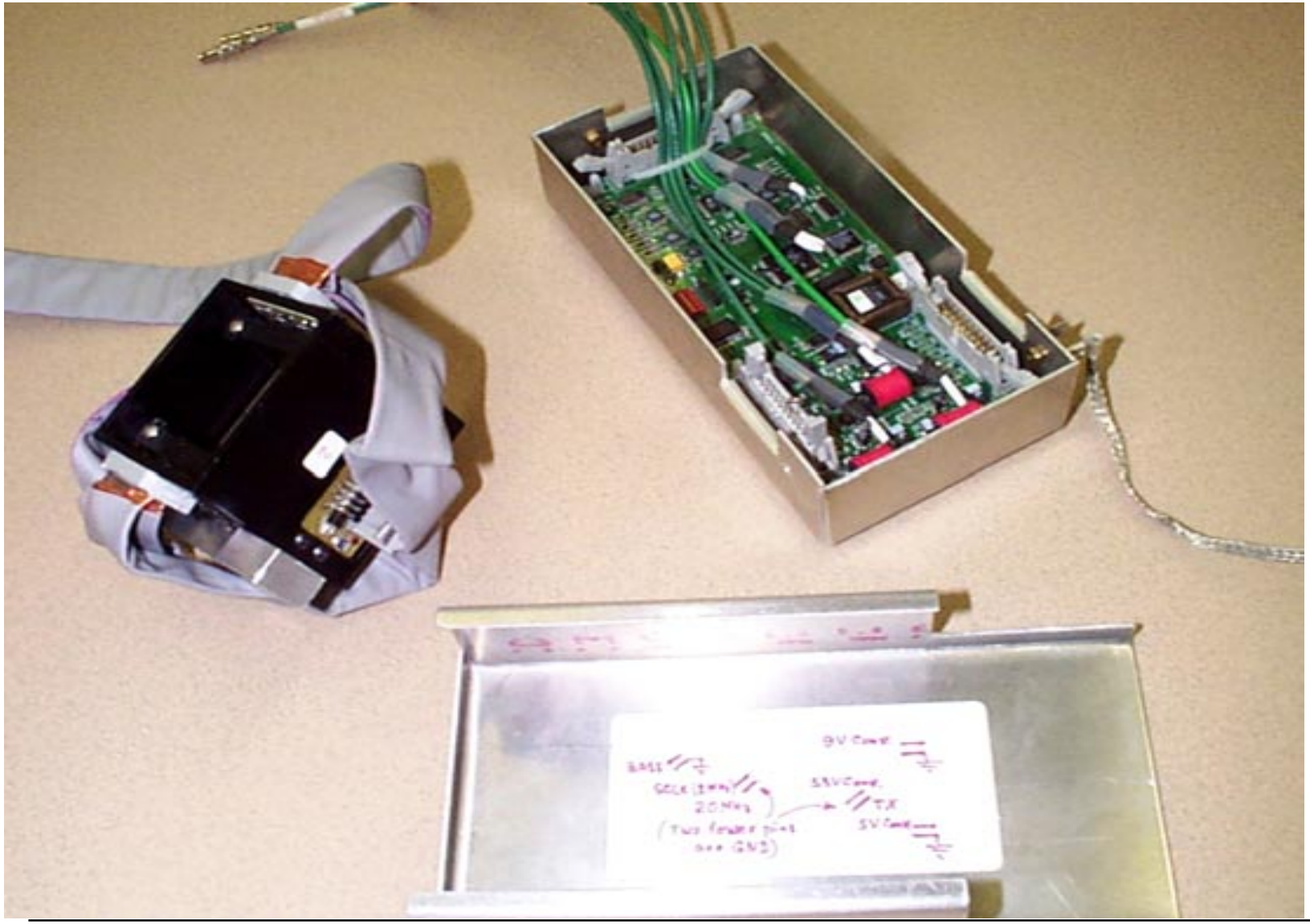
DCOPS Electronics

- New front-end boards to readout the CCDs
- DCOPS readout board built and tested - 1 per box
- DSP program written to calculate/readout centroid pixel position
- Interface boards built and tested - 6 per station
- Noise tests show no effect on CSC readout
- Boards tested in 0.5 tesla B field

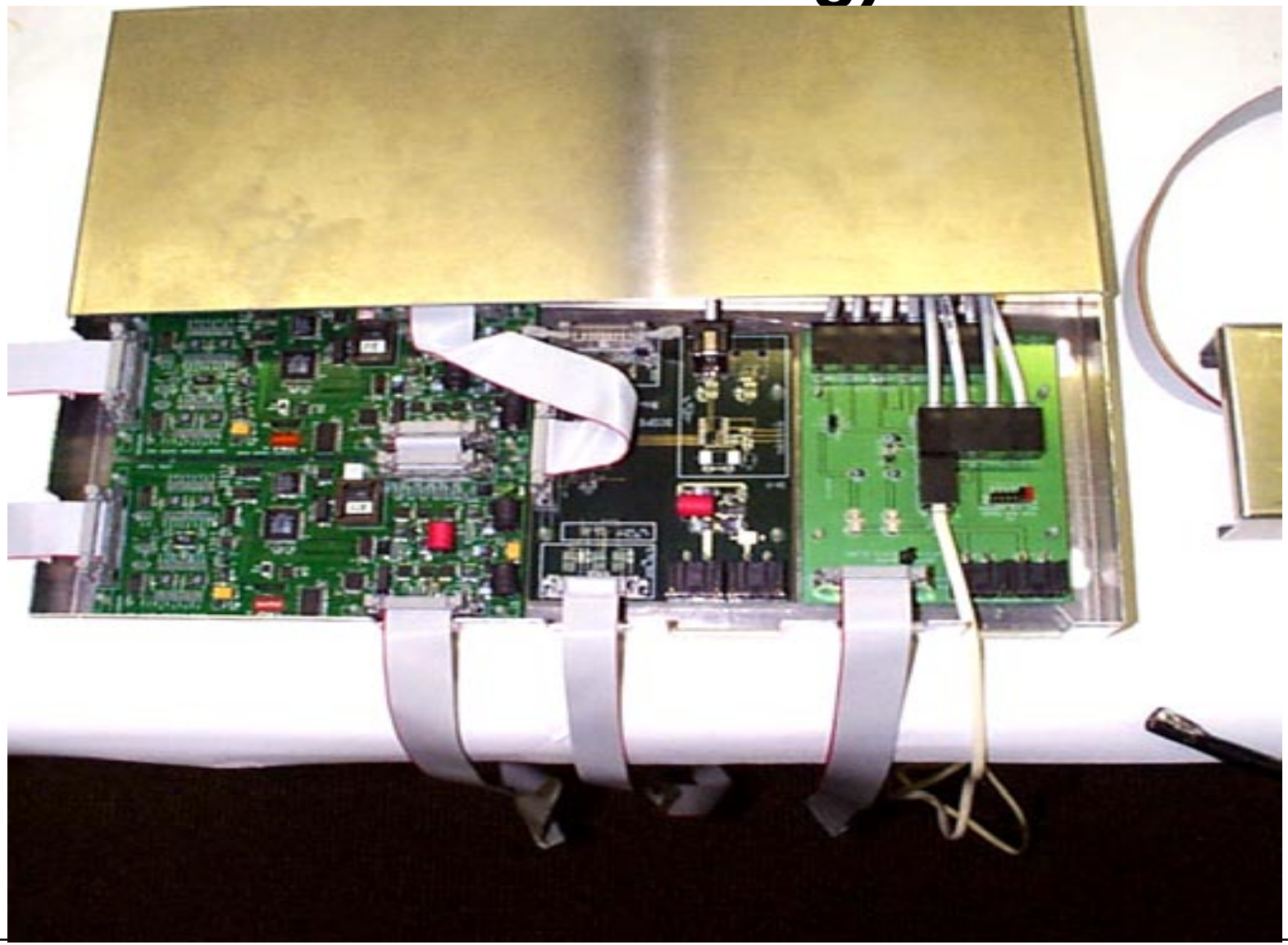
Analog electronics

- Analog, proximity sensor interface boards built & tested
- Temp. conversion board built & tested

DCOPS & Readout board



Interface boards (DCOPS & analog)



SLM Tests at Fermilab

Procedure

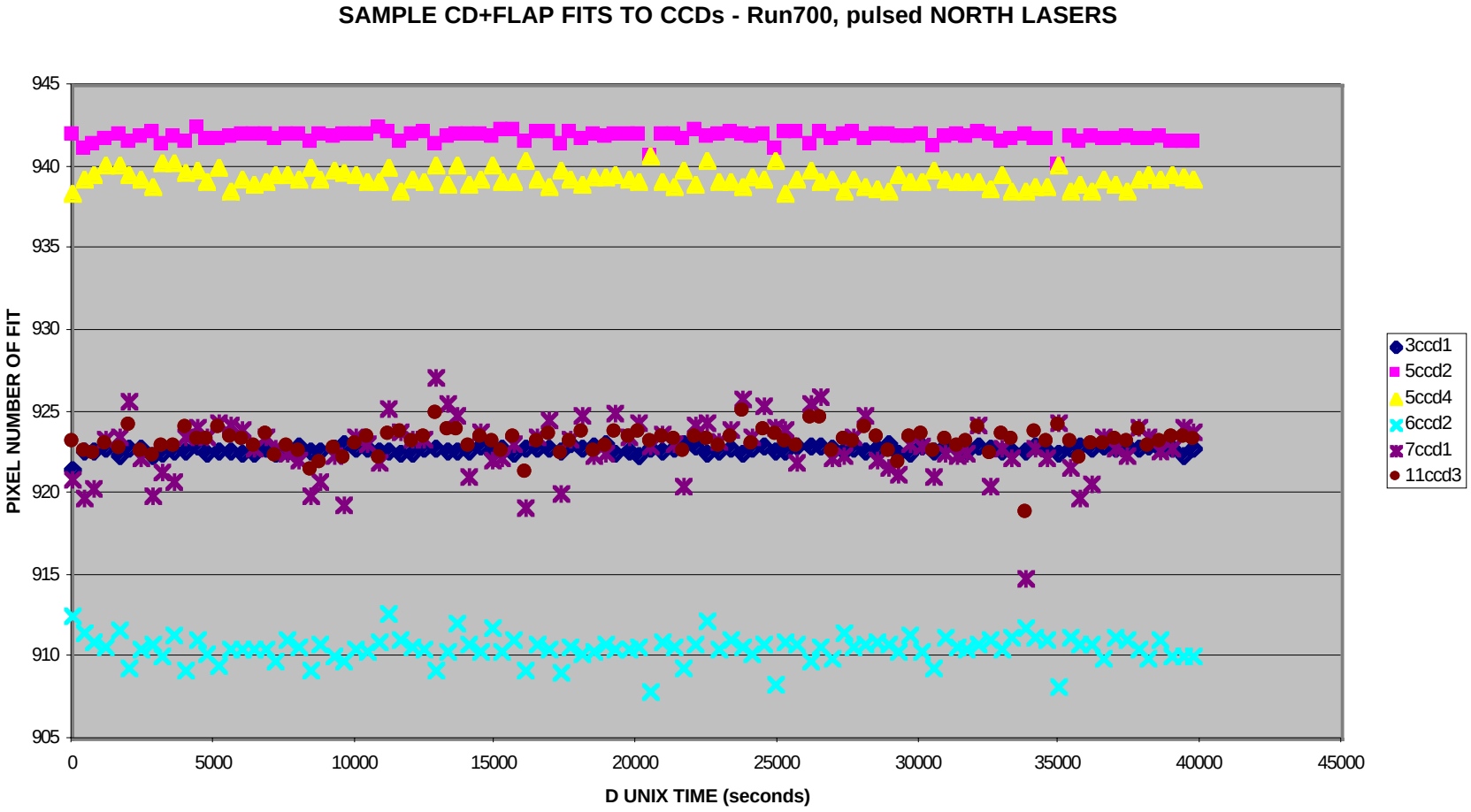
- Test setup in MW8 enclosure
- Full SLM -- 10 DCOPS sensors spaced over 14m
- Lasers at both ends
- Adjust apertures for shadowing
- Adjust laser attenuation filters to keep signal within range of the CCDs

DAQ test system

- Windows-based readout
- Read all DCOPS & analog sensors

SLM test setup

Long term SLM results



Alignment EDR

CERN Engineering Design Review

- **Held at CERN on 28 Feb - 1 Mar '02**
- **Included barrel & link groups as well as EMU**
- **Goal: approve production & commissioning**
- **Comments for EMU:**
  - Must develop design that allows operation with magnet ON and OFF
  - Since ME3 will be staged, it is important that the SLM lines can be upgraded later
  - Interface with the barrel & link alignment subsystems is critical, so a full 3D model should be developed and integrated with all alignment subsystems

EDR recommendations

EDR Committee recommends to:

- **Endorse the general Muon Alignment Scheme as presented.**
- **Make sure that, after upgrading, the alignment system can be run at zero field and nominal field without access to the CMS detector.**
- **Plan to run a representative slice of the Muon Alignment System during the Magnet test.**
- **Procure the MABs after review of the MAB prototype by an EDR sub-committee.**
- **Proceed with the procurement of all remaining elements of the alignment system for Barrel Muon, Endcap Muon, and Link Systems.**

Installation

Components installed at CERN

- Only 1/6 of CSC chambers get alignment components
- Island plates glued on just prior to CSC installation, begin in Nov ‘02
- SLM lines (mounts, towers, transfer plates) installed after CSC station is complete, expect 1st station ready for alignment in spring/summer ‘03
- Services (power, readout lines, etc.) tested for each station
- After station is complete we do photogrammetry
- Axial components installed on each disk in SX5, some testing may be possible
- Axial lines complete only in UX5

Plans for ‘02 - ‘03

DCOPS sensors

- Build & test production prototypes
- Start production on electronics & ancillary parts (filters, wedges, boxes, etc.)

SLM & Axial lines

- Build prototype transfer plate mount
- Start production for mounts & transfer plates
- Order analog sensors (radial, prox. z), etc.)

Layout

- Keep checking on CERN infrastructure & RPC drawings so alignment lines are not blocked

Conclusion

Alignment system is very close to a final DCOPS sensor

- Still some design and prototyping necessary
- Group is small but dedicated

Production of mechanical parts and electronics can start once the DCOPS is final

- Expect to start by fall ‘02
- Production drawings must be ready
- Installation should begin in early ‘03